



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6:  E21B 17/08		A1	(11) International Publication Number: <b>WO 98/26152</b>  (43) International Publication Date: 18 June 1998 (18.06.98)
(21) International Application Number: PCT/GB97/03450	(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).		
(22) International Filing Date: 12 December 1997 (12.12.97)			
(30) Priority Data: 9625939.5 13 December 1996 (13.12.96) GB			
(71) Applicant (for all designated States except US): PETROLINE WELLSYSTEMS LIMITED [GB/GB]; Offshore Technology Park, Claymore Drive, Bridge of Don, Aberdeen AB23 8GD (GB).			
(72) Inventor; and			
(73) Inventor/Applicant (for US only): METCALFE, Paul, David [GB/GB]; North Wing, Bucklerburn Steading, Peterculter AB14 0NP (GB).			
(74) Agents: McCALLUM, William, Potter et al.; Cruikshank & Fairweather, 19 Royal Exchange Square, Glasgow G1 3AE (GB).			
(54) Title: EXPANDABLE TUBING			
<p>(57) Abstract</p> <p>Expandable tubing, as utilised in downhole applications in the oil and gas exploration and extraction industries, comprises tubing having a multiplicity of overlapping longitudinally extending slots (20), the slots being wider at one or both end portions. Conveniently, the slot ends are widened by the provision of short transverse slots (22), to provide the slots with a "dog bone" appearance.</p>			

BEST AVAILABLE COPY

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslavia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece		Republic of Macedonia	TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MM	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon	KR	Republic of Korea	PL	Poland		
CN	China	KZ	Kazakhstan	PT	Portugal		
CU	Cuba	LC	Saint Lucia	RO	Romania		
CZ	Czech Republic	LI	Liechtenstein	RU	Russian Federation		
DE	Germany	LK	Sri Lanka	SD	Sudan		
DK	Denmark	LK	Liberia	SE	Sweden		
EE	Estonia			SG	Singapore		

EXPANDABLE TUBING

This invention relates to expandable tubing comprising tubing have a multiplicity of overlapping longitudinally extending slots therein. In particular, but not exclusively, the invention relates to expandable tubing as utilised in downhole applications in the oil and gas exploration and extraction industries, such as the tubing sold under the EST trademark by the applicants.

WO93\25800 (Shell Internationale Research) discloses a tubing comprising lengths of tube which have been machined to create a large number of overlapping longitudinal slots. The tube may be expanded radially outwardly by running a mandrel through the tubing.

The magnitude of the force necessary to expand the tubing is related to the number of slots in the tubing, that is the fewer the number of slots the greater the expanding force. Further, expandable tubing provided with relatively few slots is more prone to fracture and catastrophic failure of the tubing during expansion. However, forming a large number of slots in a section of tubing weakens the tubing and renders the tubing more susceptible to damage during handling and running into the borehole.

It is among the objectives of embodiments of the present invention to obviate or mitigate these difficulties.

According to the present invention there is provided

expandable tubing comprising tubing having a multiplicity of overlapping longitudinally extending slots therein, at least some of the slots being wider at one or both slot end portions.

Surprisingly, it has been found that increasing the width of the slot ends, without increasing the width of the remainder of the slot, reduces the force required to expand the tubing without reducing the strength of the tubing to any significant degree. Without wishing to be bound by theory, it is believed that the force necessary to expand a section of tubing is a function of the width of the "finger" between adjacent overlapping slots; by enlarging the slot ends, the effective width of the finger is reduced to the circumferential spacing between the adjacent enlarged slot ends.

Preferably, each slot is wider at both ends.

Preferably also, a majority of the slots in the tubing are wider at one or both end portions.

Preferably also, the wider slot end portions are symmetrical about the respective longitudinal slot axis. Conveniently, the slot end portions are widened by provision of transverse slots at the slot ends, although other slot or recess forms, such as round holes, at or adjacent the slot ends, may be utilised. Such widening of the slot ends provides slots with a "dog bone" appearance.

As used herein, the term slot is intended to encompass any cutting, machining or weakening of the tubing intended to facilitate radial expansion, including slots which

extend only partially through the tubing and which permit the remaining thinned sections to fracture or extend.

This and other aspects of the present invention will now be described, by way of example, with reference to the 5 accompanying drawings, in which:

Figure 1 is a sectional view of a length of prior art expandable tubing, shown in an expanded configuration;

Figure 2 is a sectional view on line 2 - 2 of Figure 1 and also shows the prior art tubing in unexpanded 10 configuration; and

Figure 3 is a view of a portion of the wall of expandable tubing in accordance with a preferred embodiment of the present invention.

Reference is first made to Figures 1 and 2 of the 15 drawings, which illustrate a length of conventional expandable slotted tubing 10. In its initially unexpanded configuration, the tubing 10 is simply a length of pipe in which a series of longitudinal slots 12 have been machined (shown as tube 10a with slots 12a in Figure 2). Applying 20 radially outward force to the tubing wall, for example by passing a mandrel through the tubing, causes the tube to expand such that the slots 12a become diamond-shaped openings 12b, as described in WO93\25800.

Reference is now made to Figure 3 of the drawings, 25 which illustrates a section of tubing wall in accordance with a preferred embodiment of the present invention. The tubing wall defines a series of longitudinal slots 20, each having shorter transverse slots 22 at the ends thereof. In

this particular example the slots 20 are 115 mm long, whereas the transverse slots 22 are 8 mm long. The area of tubing between adjacent overlapping slots is known as a finger 24, whereas the areas between the ends of aligned 5 slots 20, which areas are generally subject to negligible deformation during expansion, are known as nodes 26.

Testing has revealed that the magnitude of force necessary to expand a section of tubing is related to the width of the fingers 24 between the overlapping slot ends. 10 In the example illustrated in Figure 3, if the transverse slots 22 were not provided, the finger width between the slots 20 would be 11 mm. However, the provision of the transverse slots 22 reduces the effective width of the fingers 24 to only 4 mm, substantially reducing the 15 magnitude of force which is necessary to expand the tubing. Surprisingly, it has been found that providing such transverse slots does not result in a significant decrease in the strength of the slotted tubing.

It will be clear to those of skill in the art that the 20 above-described embodiment is merely exemplary of the present invention, and that modifications and improvements may be made thereto without departing from the scope of the invention.

CLAIMS

1. Expandable tubing comprising tubing having a multiplicity of overlapping longitudinally extending slots therein, at least some of the slots being wider at one or 5 both slot end portions.
2. The tubing of claim 1, wherein each slot is wider at both ends.
3. The tubing of claim 1 or 2, wherein a majority of the slots in the tubing are wider at least one end portion.
- 10 4. The tubing of claim 1, 2 or 3, wherein the wider slot end portions are symmetrical about the respective longitudinal slot axis.
5. The tubing of any of the preceding claims wherein the wider slot end portions include transverse slots at the 15 slot ends.

1/2

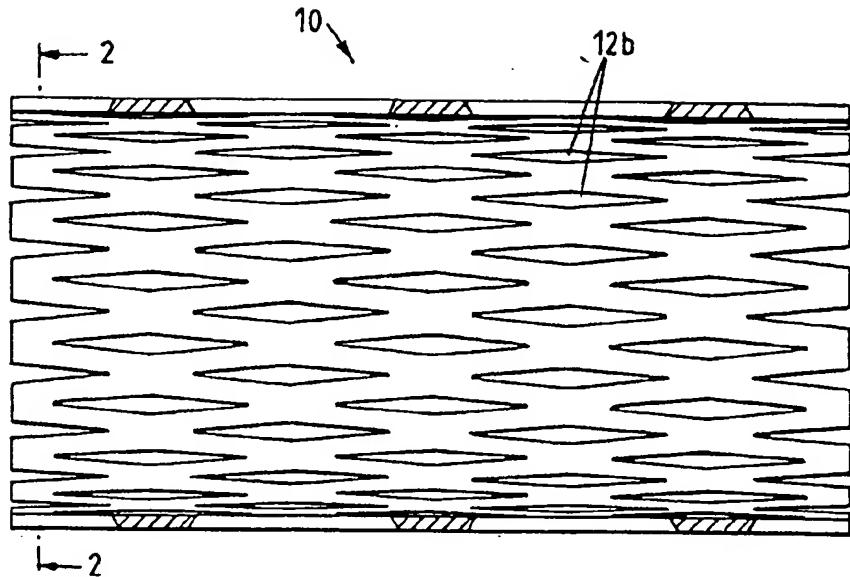


FIG. 1  
(PRIOR ART)

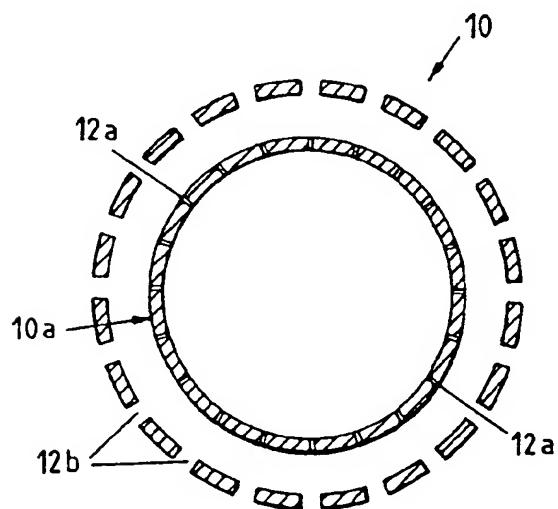
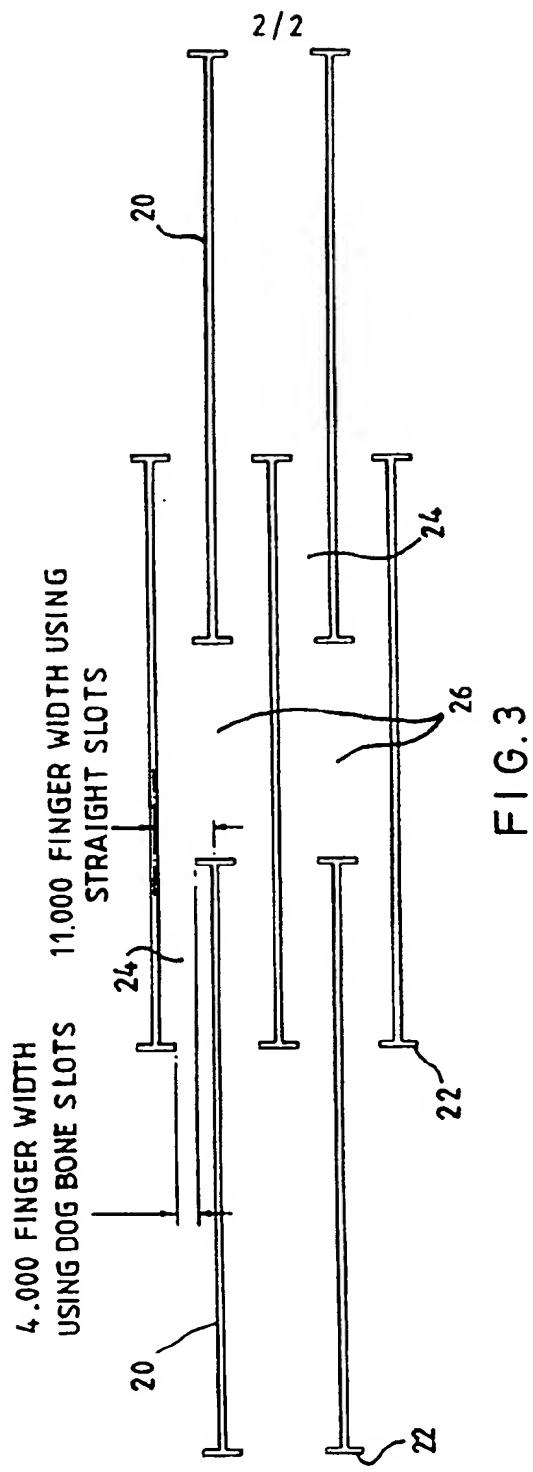


FIG. 2  
(PRIOR ART)

**SUBSTITUTE SHEET (RULE 26)**



SUBSTITUTE SHEET (RULE 26)

# INTERNATIONAL SEARCH REPORT

Intesa - 1 Application No.  
PCT/GB 97/03450

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> E 21 B 17/08							
According to International Patent Classification (IPC) or to both national classification and IPC 6							
<b>B. FIELDS SEARCHED</b> Minimum documentation searched (classification system followed by classification symbols) E 21 B, F 16 L							
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched							
Electronic data base consulted during the international search (name of data base and, where practical, search terms used)							
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left; padding: 5px;">Category *</th> <th style="text-align: left; padding: 5px;">Citation of document, with indication, where appropriate, of the relevant passages</th> <th style="text-align: left; padding: 5px;">Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td style="text-align: center; padding: 5px;">X</td> <td style="padding: 5px;">           US 4349050 A            (BERGSTROM et al.)            14 September 1982 (14.09.82),            fig. 2, claims.            --            WO 96/37681 A1            (PETROLINE WIRELINE SERVICES            LIMITED) 28 November 1996            (28.11.96),            the whole document.            --            US 2633374 A            (BOICE) 31 March 1953            (31.03.53),            the whole document.            ----         </td> <td style="text-align: center; padding: 5px;">1-4  1  1</td> </tr> </tbody> </table>		Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	US 4349050 A (BERGSTROM et al.) 14 September 1982 (14.09.82), fig. 2, claims. -- WO 96/37681 A1 (PETROLINE WIRELINE SERVICES LIMITED) 28 November 1996 (28.11.96), the whole document. -- US 2633374 A (BOICE) 31 March 1953 (31.03.53), the whole document. ----	1-4  1  1
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.					
X	US 4349050 A (BERGSTROM et al.) 14 September 1982 (14.09.82), fig. 2, claims. -- WO 96/37681 A1 (PETROLINE WIRELINE SERVICES LIMITED) 28 November 1996 (28.11.96), the whole document. -- US 2633374 A (BOICE) 31 March 1953 (31.03.53), the whole document. ----	1-4  1  1					
<input type="checkbox"/> Further documents are listed in the continuation of box C. <input type="checkbox"/> Patent family members are listed in annex.							
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed							
T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. & document member of the same patent family							
Date of the actual completion of the international search 20 March 1998	Date of mailing of the international search report 17.04.98						
Name and mailing address of the ISA European Patent Office, P.O. 5818 Patentstaan 2 NL - 2280 Rijswijk Tel. (+ 31-70) 340-2040, Telex 31 651 epo nl Fax (+ 31-70) 340-3016	Authorized officer WANKMÜLLER e.h.						

**ANHANG**

zum Internationalen Recherchenbericht über die internationale Patentanmeldung Nr.

**ANNEX**

to the International Search Report to the International Patent Application No.

**ANNEXE**

au rapport de recherche international relatif à la demande de brevet international n°

PCT/GB 97/03450 SAE 179001

In diesem Anhang sind die Mitglieder der Patentfamilien der im obengenannten Internationalen Recherchenbericht angeführten Patentdokumente angegeben. Diese Angaben dienen nur zur Orientierung und erfolgen ohne Gewähr.

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned International search report. The Office is in no way liable for these particulars which are given merely for the purpose of information.

La présente annexe indique les membres de la famille de brevets relatifs aux documents de brevets cités dans le rapport de recherche international visé ci-dessus. Les renseignements fournis sont donnés à titre indicatif et n'engagent pas la responsabilité de l'Office.

Im Recherchenbericht angeführtes Patentdokument Patent document cited In search report Document de brevet cité dans le rapport de recherche	Datum der Veröffentlichung Publication date Date de publication	Mitglied(er) der Patentfamilie Patent family member(s) Membre(s) de la famille de brevets	Datum der Veröffentlichung Publication date Date de publication
US A 4349050	14-09-82	keine - none - rien	
WO A1 9637681	28-11-96	AU A1 58265/96 AU A1 73493/96 EP A1 824628 EP A1 828918 GB A0 9510465 NO A0 975348 NO A0 975350 WO A1 9637680	11-12-96 11-12-96 25-02-98 18-03-98 19-07-95 21-11-97 21-11-97 28-11-96
US A 2633374		keine - none - rien	

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- BLACK BORDERS**
- IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- FADED TEXT OR DRAWING**
- BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- SKEWED/SLANTED IMAGES**
- COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- GRAY SCALE DOCUMENTS**
- LINES OR MARKS ON ORIGINAL DOCUMENT**
- REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- OTHER:** \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**